



**UNIVERSITI PUTRA MALAYSIA**

**INJURY CHARACTERISTICS OF MOTORCYCLISTS INVOLVED  
IN MOTORCYCLE CRASHES IN KLANG VALLEY, MALAYSIA**

**PANG TOH YEN**

**FK 2000 3**

**INJURY CHARACTERISTICS OF MOTORCYCLISTS INVOLVED  
IN MOTORCYCLE CRASHES IN KLANG VALLEY, MALAYSIA**

**By**

**PANG TOH YEN**

**Thesis Submitted in Fulfilment of the Requirements for the Degree of  
Master of Science in the Faculty of Engineering  
Universiti Putra Malaysia**

**February 2000**



**Dedicated to my beloved family:**

**Dad, Mum,**

**Brother, Sister-in-law, Sister**

**and Grandmother**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in  
fulfilment of the requirement for the degree of Master of Science.

**INJURY CHARACTERISTICS OF MOTORCYCLISTS INVOLVED  
IN MOTORCYCLE CRASHES IN KLANG VALLEY, MALAYSIA**

By

**PANG TOH YEN**

**February 2000**

**Chairman : Radin Umar Radin Sohadi, Ph.D.**

**Faculty : Engineering**

The objectives of this study were to establish the relationship between injury outcomes and i) riders' characteristics, ii) their exposure and iii) the motorcycle factors resulting from serious and fatal motorcycle crashes. Data on motorcycle crashes and injuries from January to December 1998 were obtained from two sources, namely the police reports and hospital records. These linked data were then used to examine the injury patterns sustained by the motorcyclists involved in motorcycle crashes in Malaysia. In order to assess the independent variables in influencing the injury outcome, the logistic regression method was used to determine the odds ratios and the multivariate models for the injured motorcyclists.

In the statistical analysis, a total of five independent variables were found to significantly ( $p < 0.05$ ) influence the fatality risk. Those variables were (i) age of motorcyclists, (ii) engine capacity of the motorcycles, (iii) objects struck,

(iv) type of collisions and (v) location sites. Results showed that fatality risks were likely to associate with older motorcyclists, larger engine motorcycles, collision with a heavy commercial vehicle, head-on collision, and non-junction sites.

The study also revealed that the most frequent injuries to fatally injured motorcyclists were head injuries (56.5%) and chest injuries (27.4%). Injuries to the lower limbs, however, accounted for the highest proportion (54.4%) for the serious injury cases investigated. This is followed by the upper limb injuries (19.9%). Most motorcyclists were detained for one or two nights for observation and recovery. The mean stay for all patients were about 5 days. However, those motorcyclists who suffered from lower limb injuries often required longer stay in hospital.

In addition, the study indicated that side collisions presented a difficult problem in crash protection towards the lower limbs. Despite the fact that most motorcycles in Malaysia had very little crushable and protective structure around the rider's lower limb region. Whereas, this kind of protection was found to reduce the risk of lower limb injuries in many studies. As such, further investigation on the design of effective leg protector for motorcyclists should be carried out.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

**SIFAT-SIFAT KECEDERAAN PENUNGGANG MOTOSIKAL  
AKIBAT KECELAKAAN MOTOSIKAL DI LEMBAH KLANG, MALAYSIA**

Oleh

**PANG TOH YEN**

**Februari 2000**

**Pengerusi : Radin Umar Radin Sohadi, Ph.D.**

**Fakulti : Kejuruteraan**

Objektif kajian ini adalah untuk membentuk perhubungan antara (i) individu, (ii) pendedahan trafik dan (iii) faktor-faktor kenderaan dengan tahap kecederaan akibat daripada kecelakaan parah dan maut yang melibatkan pengguna motosikal di Malaysia. Data kecelakaan jalan raya dan kecederaan yang melibatkan motosikal daripada Januari hingga Disember 1998 telah diperolehi daripada dua sumber utama iaitu laporan polis dan rekod hospital. Laporan polis dan data hospital tersebut telah dikait dan digunakan untuk memeriksa corak kecederaan dan faktor penyumbangan kepada kecederaan penunggang motosikal di Malaysia. Untuk menilai pembolehubah-pembolehubah yang mempengaruhi tahap kecederaan, kaedah regresi logistik telah digunakan untuk menentukan nisbah kebarangkalian dan membentuk model multivarite.

Daripada analisa statistik, didapati terdapat sebanyak lima pembolehubah bererti ( $p < 0.05$ ) yang mempengaruhi tahap kecederaan. Antara pembolehubah tersebut ialah (i) umur penunggang (ii) saiz enjin motosikal, (iii) objek perlanggaran, (iv) jenis perlanggaran dan (v) tempat kejadian. Keputusan menunjukkan risiko kematian adalah tinggi pada golongan yang lebih tua, mereka yang menunggang motosikal yang berkuasa tinggi, berlanggar dengan kenderaan komersil, perlanggaran depan dengan depan, dan perlanggaran yang berlaku di jalan lurus tanpa simpang.

Daripada kajian yang dilakukan, didapati juga kecederaan utama yang dialami oleh mangsa yang meninggal dunia akibat kecelakaan jalan raya adalah pada bahagian kepala (56.5%). Ini diikuti dengan kecederaan pada bahagian dada (27.4%). Walau bagaimanapun, kecederaan pada anggota kaki adalah yang paling tinggi (54.4%) bagi kecederaan parah. Ini diikuti pula dengan kecederaan pada anggota tangan (19.9%). Kebanyakan penunggang motosikal dikehendaki tinggal dalam wad selama satu atau dua hari untuk pemerhatian dan penyembuhan. Purata hari tinggal dalam hospital bagi semua pesakit akibat daripada kecelakaan adalah 5 hari. Golongan penunggang motosikal yang menerima kecederaan pada bahagian anggota kaki bagaimanapun dikehendaki untuk tinggal lebih lama dalam hospital.

Selain itu, kajian ini menunjukkan bahawa perlanggaran sisi menimbulkan masalah yang rumit dalam perlindungan kecederaan pada bahagian kaki. Ini

adalah kerana kebanyakan motosikal di Malaysia mempunyai hanya sedikit struktur kebolehlanggaran dan perlindungan pada bahagian kaki penunggang. Pada hal struktur kebolehlanggaran dan perlindungan ini telahpun dilaporkan boleh mengurangkan risiko kecederaan pada bahagian kaki dalam banyak kajian yang lepas. Oleh yang demikian, kajian lanjutan ke atas keberkesanan rekabentuk alat perlindungan kaki untuk para penunggang perlu diadakan.



## ACKNOWLEDGEMENTS

It is indeed a great pleasure to acknowledge my indebtedness to those who have provided me with great help and assistance upon the completion of this research study. First and foremost, I would like to express my most sincere thanks and appreciation to Assoc. Prof. Ir. Dr. Radin Umar for his guidance, advice and constructive criticism throughout the course of this study. I would like to record my appreciation for the valuable comments and guidance given by Dr. Azhar Abdul Aziz, Emergency Medical Specialist, Hospital Universiti Kebangsaan Malaysia. I also wish to extend my gratitude to Dr. Megat Mohamad Hamdan Megat Ahmad and Dr. Mohd. Nasir Mohd. Taib for their support, constructive criticisms and valuable comment in making this study a success.

I would like to thank the Ministry of Transport, Malaysia for the research fund of Motorcycle Safety Programme. This has enabled me to complete the study without encountering any financial difficulties.

I would also like to express my deep appreciation to all the staff members of Hospital Kajang (HK), Hospital Kuala Lumpur (HKL) and Hospital UKM (HUKM) who were of great help during the data collection phase. In particular, special thanks go to Dr. Zaidah bt. Hussain (former Director, HK), Mr. Gopal, Mrs. Zanariah, Mrs. Salamah and their colleagues in HK, Dr. Lim Kuan Joo (Director of HKL) and his colleagues Dr. T. Mahadevan and Ms.

Shamsinar, Dr. Abu Hassan Assari (Head of Emergency Department, HKL), Dr. Siti Rubiah Ibrahim and Mr. How (Emergency Department, HKL), Dr. Abdul Halim (Head of Forensic Department, HKL), Dr. Zahari Noor and Dr. Mohd. Shafie (Forensic Department, HKL), Dato' Dr. Borhan Tan (Head of Orthopaedic Department, HKL), Dato' Dr. Mahmud (Head of Surgical Department, HKL) and the staff of Neurosurgery Department, HKL. I also wish to express my sincere thanks to Assoc. Prof. Dr. Shahrom Abdul Wahid and his colleagues (Forensic Department, HUKM).

I am deeply indebted to Dr. Ahamedali M.H from Birmingham University for his valuable help and advice, and Assoc. Prof. Dr. Harwant Singh, Faculty of Medicine and Health Sciences, UPM, for his valuable advice.

My deep appreciation goes to all the police officers from both Kajang and Jalan Bandar Police Stations, in particular ASP Nik Lokman from Kajang Police Station and ASP Saiful Bahri from Jalan Bandar Police Station, who provided various assistance that contributed towards the success of this study.

I would like to express my sincere thanks to other postgraduate students in the research centre, particularly Mr. Law Teik Hua, Mr. How Chee Keong, Mr. Kulanthayan S., Mr. Mohd Faudzi, who have been great friends and helpful in many aspects. I would also like to extend gratitude to all my friends for the discussion, continuous support and encouragement.

Last but not least, may my family be blessed with good health, long life and happiness for all the love and care they have given me all this while. Thanks also for always having faith in me.

x



I certify that an Examination Committee met on 1<sup>st</sup> February, 2000 to conduct the final examination of Pang Toh Yen on his Master of Science thesis entitled "Injury Characteristics of Motorcyclists Involved in Motorcycle Crashes in Klang Valley, Malaysia" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

**ABDEL MAGID HAMOUDA, PhD.**

Faculty of Engineering  
Universiti Putra Malaysia  
(Chairman)

**RADIN UMAR RADIN SOHADI, PhD.**

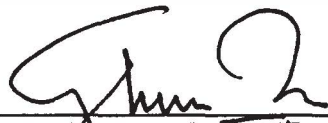
Associate Professor/Dean  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

**MEGAT MOHAMAD HAMDAN MEGAT AHMAD, PhD.**

Head  
Department of Mechanical and Manufacturing Engineering  
Faculty of Engineering  
Universiti Putra Malaysia  
(Member)

**MOHD. NASIR MOHD. TAIB, DrPH.**


Faculty of Medicine and Health Sciences  
Universiti Putra Malaysia  
(Member)



**MOHD. GHAZALI MOHAYIDIN, Ph.D.**  
Professor/Deputy Dean of Graduate School

Date: **10 MAR 2000**

This thesis was submitted to the Senate of Universiti Putra Malaysia and was accepted as fulfilment of the requirements for the degree of Master of Science.

  
KAMIS AWANG, Ph.D.  
Associate Professor,  
Dean of Graduate School,  
Universiti Putra Malaysia.

Date: 11 MAY 2000

## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



(PANG TOH YEN)

Date: 10/3/2000

## TABLE OF CONTENTS

	<b>Page</b>
<b>DEDICATION</b>	<b>ii</b>
<b>ABSTRACT</b>	<b>iii</b>
<b>ABSTRAK</b>	<b>v</b>
<b>ACKNOWLEDGEMENTS</b>	<b>viii</b>
<b>APPROVAL SHEETS</b>	<b>xi</b>
<b>DECLARATION FORM</b>	<b>xiii</b>
<b>LIST OF TABLES</b>	<b>xvii</b>
<b>LIST OF FIGURES</b>	<b>xx</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xxi</b>
 <b>CHAPTER</b>	
 <b>I        INTRODUCTION</b>	 <b>1</b>
Background of the Study	2
Problem Statement	6
Objectives	6
Hypotheses	7
Definition of Terms	8
Organisation of the Thesis	10
 <b>II        LITERATURE REVIEW</b>	 <b>11</b>
Age	11
Gender	14
Riding Experience of Motorcyclists	16
Engine Size	18
Injury Patterns in Motorcycle Crashes	20
Causes of Injuries	25
Objects Struck	30
Types of Kinematics	32
Lower Limb Injuries	33
Head Injuries	38
Special Problem: Loss of Helmets	41
Statistical Analysis Method	43
Conclusion	48
 <b>III       METHODS AND MATERIALS</b>	 <b>49</b>
Methodology	49
Sample Selection	52
Geographical Area of Data Collection	52

Instruments Used	53
Accident Interview Form	53
Motorcycle Inspection Form	54
Injury Data Form	55
Vehicle Inspection	56
Vehicle Damage Configuration	56
The Need of CDC	57
Photographs	58
Injury Data	58
Injury Severity	59
Injury Severity Score	60
Clothing Inspection	60
Case Compilation	61
Data Organisation	62
Statistical Analysis	62
Resource Limitations	64

<b>IV</b>	<b>RESULTS: INJURY CHARACTERISTICS OF INJURED MOTORCYCLISTS</b>	65
	Distribution of Injuries with MAIS by Body Region	66
	Injury Characteristics of Fatally Injured Motorcyclists	67
	Head Injuries	68
	Safety Helmets	69
	Cervical Spine Injuries	71
	Chest Injuries	72
	Abdominal Injuries	73
	Lower Limb Injuries	74
	Sources of Fatal Injuries	75
	Non-Fatal Injuries	77
	Head Injuries	77
	Spine Injuries	78
	Upper Limb Injuries	79
	Lower Limb Injuries	80
	Sources of Non-fatal Injuries	84
	Conclusion	86

<b>V</b>	<b>RESULTS: STATISTICAL ANALYSIS AND MODELLING OF MOTORCYCLE CRASHES</b>	87
	Characteristics of Motorcyclists	88
	Age and Gender	89
	Riding Experience	91
	Crashes by Engine Capacity	92
	Crashes by Objects/Vehicles Struck	94
	Crashes by Collision Type	96
	Crashes by Road Type	97



	Time and Day of Crashes	98
	Multivariate Analysis	100
	Data Structure	101
	Modelling Technique and Goodness of fit	101
	Final Model	103
	Conclusion	104
<b>VI</b>	<b>DISCUSSION AND CONCLUSIONS</b>	<b>105</b>
	Fatally Injured Motorcyclists	105
	Head Injuries	106
	Cervical Spine Injuries	107
	Thoracic Injuries	108
	Injuries Descriptions	109
	Non-Fatal Injuries	110
	Characteristics of the Riders	112
	Age	113
	Gender	115
	Riding Experience	116
	Engine Capacity	117
	Crash Circumstances	118
	Obstacles	119
	Collision Types	120
	Location Sites	121
	Conclusion	122
	Recommendations	124
	<b>BIBLIOGRAPHY</b>	<b>128</b>
	<b>APPENDICES</b>	
	A Accident Interview Form	136
	B Motorcycle Inspection Form	142
	C Injury Data Form	152
	D Output of Multivariate Analysis	155
	<b>VITA</b>	<b>163</b>

## LIST OF TABLES

Table	Page
2.1 Motorcyclist Casualty Rates, 1986	19
2.2 Injury Patterns and Severity Sustained by Motorcyclists	21
2.3 Distribution of Injuries by Severity	22
2.4 Somatic Injury Distribution – All Severities	23
2.5 Frequency of Injuries by Head-Neck Region	24
2.6 Objects Causing Injury to Motorcyclists by Severity	26
2.7 Injury Severity by Objects Struck	28
2.8 Frequency of Objects Struck by Motorcycles	30
2.9 Objects Hit by Motorcycles	31
2.10 Frequency and Severity of Lower Extremity Injuries	36
2.11 Structure Involved in Principal Leg Injury	37
2.12 Retention System Failures	42
4.1 Frequency of Injuries Rated AIS $\geq 3$ Sustained by Fatalities	68
4.2 Source of Most Severe Head Injuries in Fatalities	69
4.3 Head Injuries and Helmet Wearing during Fatal Motorcycle Crashes	70
4.4 Summary of Fatalities with Cervical Spine Injuries	72
4.5 Distribution of Abdominal Injuries in Fatally Injured Motorcyclists	73
4.6 Collision Types against Objects Struck in Fatal Motorcycle Crashes	76
4.7 Summary of Non-Fatal Motorcyclists with Spine Injuries	79



4.8	Distribution of Upper Limb Injuries with AIS $\geq 2$ by Casualties	80
4.9	Distribution of Overall Injuries to the Lower Limbs of Motorcyclist Casualties	81
4.10	Lower Limb Injuries against Type of Collision in Motorcycle Crashes	84
4.11	Collision Types against Objects Struck in Non-fatal Motorcycle Crashes	85
5.1	Summary of Motorcyclist Characteristics	88
5.2	Odds Ratios and 95% Confidence Interval by Age (as a continuous variable) of Motorcyclists in Motorcycle Crashes	90
5.3	Odds Ratios and 95% Confidence Interval by Age of Motorcyclists in Motorcycle Crashes	91
5.4	Odds Ratios and 95% Confidence Interval by Riding Experience in Motorcycle Crashes	92
5.5	Distribution of Motorcyclist by Age Group and Engine Capacity	93
5.6	Odds Ratios and 95% Confidence Interval by Engine Capacity of Motorcycles in Motorcycle Crashes	94
5.7	Vehicles/Objects Struck by Motorcyclists during Motorcycle Crashes	94
5.8	Odds Ratios and 95% Confidence Interval by Objects Struck in Motorcycle Crashes	95
5.9	Collision Type in Motorcycle Crashes	96
5.10	Odds Ratios and 95% Confidence Interval by Collision Type in Motorcycle Crashes	97
5.11	Road Travelled-on by Motorcyclists during Motorcycle Crashes	97

5.12	Odds Ratios and 95 % Confidence Interval by Type of Location in Motorcycle Crashes	98
5.13	Description of Variables Included in the Multivariate Analysis	101
5.14	Logistic Regression on Fatality Risk Resulting from Motorcycle Crashes in Malaysia	104

## LIST OF FIGURES

Figure	Page
1.1 Total Number of Registered Motorcycles and Total Number of Fatally Injured Motorcyclists in Road Crashes	2
1.2 Number of Deaths for Car and Motorcycle Road Users	3
1.3 Total Number of Motorcycle Casualties by Age Group in 1997	5
3.1 Flow Chart of Data Collection on Motorcycle Crashes in Malaysia	51
4.1 Injury Distribution of Motorcyclist Casualties with MAIS by body Region	66
4.2 Distribution of Lower Limb Fracture to the Bony Tissues of Fatalities by Anatomical Region	74
4.3 Injury Distribution of Non-fatal Motorcyclist Casualties with MAIS by Body Region	78
4.4 Distribution of Lower Limb Fracture to the Bony Tissues of Non-fatal Motorcyclists by Anatomical Region	82
4.5 Number of Hospital In-patients and Length of Stay	83
5.1 Distribution of Motorcyclist against Outcome	89
5.2 Distribution of Motorcycle Riders by Experience	92
5.3 Distribution of Motorcycle Crashes by Hour of Day	99
5.4 Distribution of Motorcycle Crashes by Day of Week	100

## LIST OF ABBREVIATIONS

95% CI	95% Confidence Interval
AIS	Abbreviated Injury Scale
CT	Computed Tomographic
HCVs	Heavy Commercial Vehicles
HKL	Hospital Kuala Lumpur
HUKM	Hospital Universiti Kebangsaan Malaysia
ISS	Injury Severity Score
LCVs	Light Commercial Vehicles
MAIS	Maximum Abbreviated Injury Scale
OR	Odds Ratios
PC	Personal Computer
PDRM	Royal Malaysia Police
RSRC	Road Safety Research Centre
SPSS	Statistical Package for Social Science
UPM	Universiti Putra Malaysia

## **CHAPTER I**

### **INTRODUCTION**

This thesis describes a study on motorcycle crashes and injury characteristics of motorcyclists within the context of Malaysia. The overall objective of this study was to obtain a complete picture on the circumstances of motorcycle crashes, and also to identify the injury causes. In order to make any mode of transport safe, it is necessary to understand how accidents occurred, the causes of injuries, and the nature of contact during the crash. Then it may be possible to take some effective remedial actions to reduce the likelihood of crashes and to minimise the severity of injuries on motorcyclists during an accident.

Initially, this chapter considers the background of the study which includes the overall registered motorcycles in Malaysia. It then describes motorcycle crashes and injury rates in Malaysia, leading to the identification of the magnitude and seriousness of the motorcycle safety problem.

## Background of the Study

The motorcycle is a major mode of personal transport in Malaysia, because it is relatively affordable and 'reliable' compared to other motor vehicles. As such, about 53% of the registered vehicles in this country are motorcycles. In addition, for the last decade or so, the number of registered motorised two-wheelers (motorcycles and scooters) increased tremendously from 830,834 in 1976 to 4,328,997 in 1997 (Figure 1.1). Consequently, motorcycle crashes also increased dramatically during that period from 18,187 in 1978 to 80,100 in 1997. Likewise, the annual motorcycle fatalities rose in the same period from less than 400 in 1976 to 3,760 in 1997 (PDRM 1993, 1997).

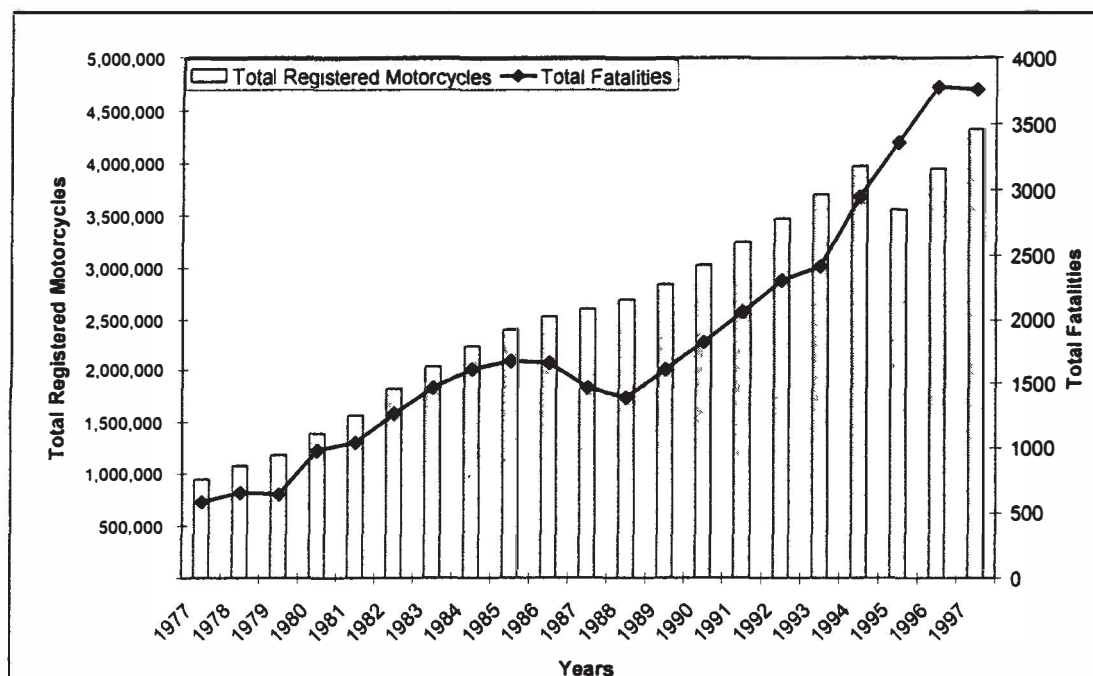


Figure 1.1: Total Number of Registered Motorcycles and Total Number of Fatally Injured Motorcyclists in Road Crashes.  
(Source: Royal Malaysia Police (PDRM) 1993, 1997)



The increased popularity of motorcycles and the concurrent rise in motorcycle crashes had led to the recognition that the motorcycle was associated with higher risk of death or injury than any other forms of transportation. In Malaysia, it is reported that the overall relative risk is about 20 times greater for motorcycles than passenger cars (Radin et al. 1995). Likewise, it can be seen that the average annual increase in motorcycle fatalities is greater than that of car (Figure 1.2). This increase, however, should be seen against the increased motorcycle ownership in the country (Figure 1.1). Therefore, it is not surprising that motorcycle riders and the pillioners constituted almost 60%, an alarmingly high percentage of death in road traffic crash in 1997.

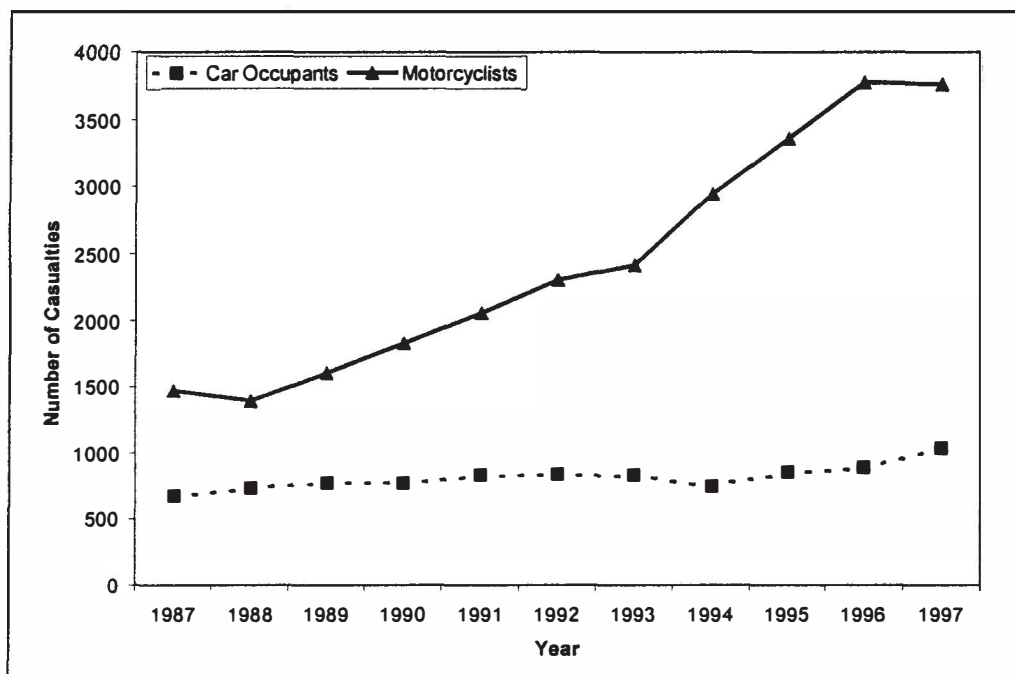


Figure 1.2: Number of Deaths for Car and Motorcycle Road Users  
(Source: Royal Malaysia Police (PDRM) 1997)